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ABSTRACT

In the action-research phase of the Learning in Science Project, four groups of people worked on problems identified in the project's second (in-depth) phase. The Chemistry Action-Research Group considered problems related to the teaching and learning of ideas associated with particles and physical/chemical changes. Based on findings during the in-depth phase, three units were developed, each unit containing: (1) information on children's and scientists' ideas related to phenomena considered in the unit; (2) a survey to help teachers clarify their own views and to establish views of students in their classrooms; and suggested teaching activities designed to modify children's views to help them make more sense of their world. The first unit ("Burning") focuses on the burning of a candle. The second unit ("Reactions") examines a range of phenomena, each of which involves a chemical reaction. The third unit ("Heating and Cooling") considers what happens when things are heated and introduces a simple particle model to explain what is happening. Each of the units was then field tested. Results of the testing for the "Burning" and "Heating and Cooling" units are presented and discussed, focusing on the extent to which children's views changed before and after the unit. (JN)

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LEARNING IN SCIENCE PROJECT

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TOWARD SOLUTIONS:

The work of the

Chemistry Action-Reseach Group

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WORKING PAPER No. 35

LEARNING IN SCIENCE PROJECT

The Chemistry Action-Research Group (1981-1982)

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THE WORK OF THE CHEMISTRY ACTION-RESEARCH GROUP

Roger Osborne, Brendan Schollum and Sue Russell

INTRODUCTION

In the action-research phase of the Learning in Science Project four groups of people worked on problems identified in the in-depth phase of the Project. The Chemistry Action-Research Group considered problems related to the teaching and learning of ideas associated with particles and changes; problems which had been earlier identified in the three working papers, Particles (No.18), Physical Change (No.26) and Chemical Change (No.27).

The group was chosen to provide a variety of experiences in teaching and a range of academic backgrounds in chemistry. It consisted of practising classroom teachers including Learning in Science Project team members. Prior to the first meeting of the group in June 1981 individual team members were sent the three working papers of the in-depth phase - Particles, Chemical Change, and Physical Change - and asked to consider whether the problem and difficulties described in these papers related to real, important and solvable issues.

THE FIRST MEETING

There was a wide ranging discussion of the problems involved in teaching chemistry at the 1-4 level. The discussion emerged from points which had been both explicitly and implicitly raised by the working papers.

Of major concern was the place of the particle model in junior chemistry teaching. Questions raised included;

i) Should or can a particle model of the states of matter be taught?

ii) If so, what aspects of a particle model should or can be taught to whom?

These questions seem to be ones that groups of chemistry teachers everywhere have difficulty resolving and hence it is not surprising that the action-research group had some difficulty attempting to resolve this point also.

Nevertheless, it was agreed that;

a) Chemistry is, and should be, the study of things changing into other things. To this end we need to encourage children to identify groups of similar changes, e.g. various things evaporating, various things burning, and things melting or dissolving (including their differences).

b) Children have ideas about how and why particular events do occur, but these ideas are frequently quite different from the scientific viewpoint. From this perspective teaching chemistry needs to be seen as a reshaping, or modifying of children's ideas rather than transmitting new knowledge to blank minds.

c) A particle model should be introduced only as and when it is necessary to help children make sense of new experiences and where it will help them to replace their views about certain changes with a more intelligible, plausible and useful viewpoint. However, it is essential that it is the child who considers the new viewpoint as more intelligible, plausible and useful and not the teacher! The particle model should arise from a perceived need by the pupils.

d) So that new ideas about changes are linked to, build on and modify old ideas it is important that many of the changes that are considered are familiar changes, e.g. found in the home. It is necessary to break down the view that "science is something done to us by strange people (science teachers) in strange rooms (science laboratories) using strange materials (equipment and uncommon chemicals)".

e) Many activities have to be used to establish concepts such as "dissolving" and "burning". Many illustrations are required.

f) It would be desirable that activities used to modify children's ideas related to contexts where a knowledge of children's ideas is already known, viz. contexts used in the in-depth phase interviews, e.g. rusting, burning of a candle, boiling of water.

g) One of the key ideas which children need to really appreciate is that when changes occur matter is neither created nor destroyed.

THE FOLLOWING MEETINGS

The group met again on three occasions, in August, October and November. Before the August meeting many of the group had surveyed pupils with trial survey material which, in modified form, can now be found in the units produced by the group. Also, various members of the group had explored in an ad-hoc way teaching strategies, some original, and some borrowed from other sources which may have resolved some of the issues discussed at the first meeting. At each of the meetings these strategies were discussed so that further trialling, refining, and evaluation could occur.

a) Two group members (T.B. and J.N.) discovered and used a chapter "A candle burning" from Integrated Science Book 2, Wreake Valley Project. This unit was considered potentially useful, in terms of helping children learn more about a familiar set of changes and confronting some of the ideas children hold about burning. Initial trials with the material and evaluation of the burning that had occurred suggested the unit could be adapted to provide a useful unit of work.

b) Three members (P.S., A.C. and T.M.) investigated problems related to the particle model. Survey questions which investigated by pictorial representations children's ideas of the particle nature of matter were developed. Situations and activities which might help pupils develop a particular model were investigated tentatively.

c) Three other members (R.T., K.D. and S.B.) explored children's skills of observation and use of the other senses in the context of dissolving. Children's ideas about what was happening when something dissolves were brought into the open and these ideas explored by activities and discussion.

d) Three members (P.F., A.C. and T.M.) considered children's views about the boiling and condensing of water and how these ideas might be modified by activities and discussion.

Group members further considered the role of the particle model in chemistry teaching and considered the desirability or otherwise of attempting to distinguish between chemical and physical changes at the Form 1-4 level. The view that the particle model should be introduced as and when it was appropriate to help children make sense of their experiences was reiterated. The distinction between physical and chemical changes was considered to be not entirely helpful or useful even to chemists.

As a result of the work done by the group between these meetings, and in the light of further discussion it was agreed to work toward producing units for teachers. As a theme for the units it was decided to consider the various changes that occur when familiar things are heated or mixed together. Three units were planned and it was decided that each unit would contain:

i) Information on children's ideas related to the phenomena to be considered in the unit.

ii) Information on the scientists' ideas related to the phenomena to be considered in the unit.

iii) A survey to help teachers clarify their own views and to establish the views of pupils in their classrooms.

iv) Suggested teaching activities designed to modify children's views in a way which would help children make more sense of their world.

THE THREE UNITS

On the above outline the three units developed were;

a) Working Paper No. 36: Burning

This unit focuses on the burning of a candle. The rationale here is that a great deal can be found out about one particular type of chemical reaction using this everyday phenomena. This enables pupils to link such understandings to their view of the world.

b) Working Paper No. 37: Reactions

The unit focuses on a range of phenomena, each of which involves a chemical reaction. Also considered are substances being mixed which do not result in chemical reactions so that a comparison can be made. Again

the overriding concern is to try to use everyday phenomena as far as is possible so that children can modify their own intuitive ideas rather than learn chemistry as something which does not relate to their world. Several familiar reactions, e.g. rusting are looked at in greater detail.

As well, what happens when substances dissolve is clarified. Emphasis is centred on the idea that at this level these need not be considered as chemical reactions.

c) Working Paper No. 38: Heating and Cooling

This unit begins by considering what happens when things are heated. Three types of changes are identified.

i) the change is not obvious, temporary, and easily reversed, e.g. the heating of iron causing expansion.

ii) the change is obvious, temporary, and easily reversed, e.g. the forming of ice.

iii) the change is obvious, seems permanent, and is very difficult to reverse, e.g. the heating of sugar, the burning of a candle.

This working paper considers i) and ii) only. A simple particle model is introduced during the unit as a useful explanation for things that have been observed to happen. Further evidence for particle motion is then discussed. Changes of type iii) are considered in the other units (see above).

TRIALS OF THE MATERIALS

At this stage (September 1982) the material produced by the Chemistry Action Research Group is still under testing and further development. Nevertheless the following two sets of results, one for the Burning unit and the other for the Heating and Cooling unit, give an indication of the

type of results being obtained and their implications for further work.

Burning: The results provided here give details of the trialling carried out in one school during 1982 on Working Paper No. 36.

The Unit was taught as presented in the paper to three 3rd form classes in a girls' school by three different teachers. Two of these teachers were reasonably familiar with the Learning in Science Project material while the third teacher was given a brief introduction to LISP. Pupils in the three classes were surveyed using the survey in the Unit (see Appendix A) before, shortly after and three months later (no revision). The results presented below are from some 60 Form 3 pupils taught by the two teachers familiar with LISP. The classes were above average classes with TOSCA medians of 92% and 76%. The results of the third class are not included although they largely reinforced the trends which follow for the two classes whose results are provided.

Question 1: The results for question 1 are provided in Figure 1. It is interesting to note that with these more able pupils 70% of them already held the scientific view prior to teaching. This percentage is significantly lower when the full ability range of a typical school is considered. The continued tendency toward a more scientific perspective during the three months following teaching only involves a few children. However it is a tendency that has occurred elsewhere (see LISP Working Paper No. 32 - The Work of the Physics Action Research Group).

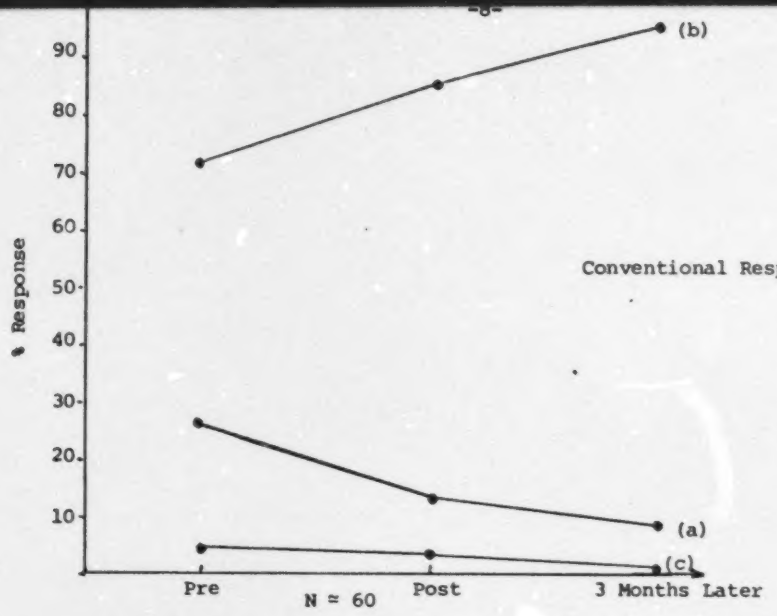


Figure 1: The Results for Question 1

Question 2: Only 2% of the pupils in the pre-survey considered the wax had any chemical function. The post-test results (see Figure 2) show a dramatic change. However it is rather interesting that a slight shift occurred during the following three months!

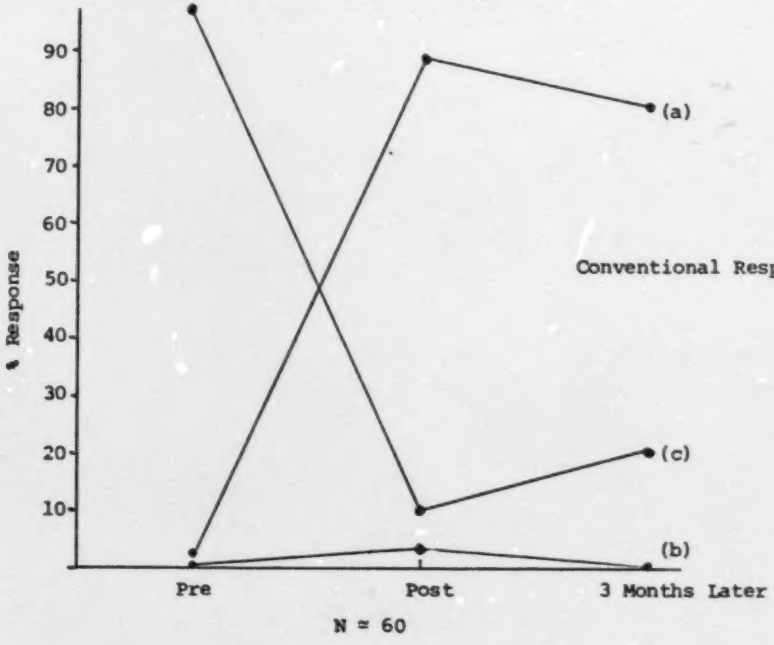


Figure 2: The Results for Question 2

Question 3: Again the results (see Figure 3) showed some dramatic changes. However this is a specific result observed by pupils during the teaching sequence. 1 gram loss occurred in 10 minutes. This was detected by pupils using an electronic balance after failing to obtain any observable change using kitchen scales. Despite direct observation it is interesting that one pupil considered it was more after 3 months reflection!

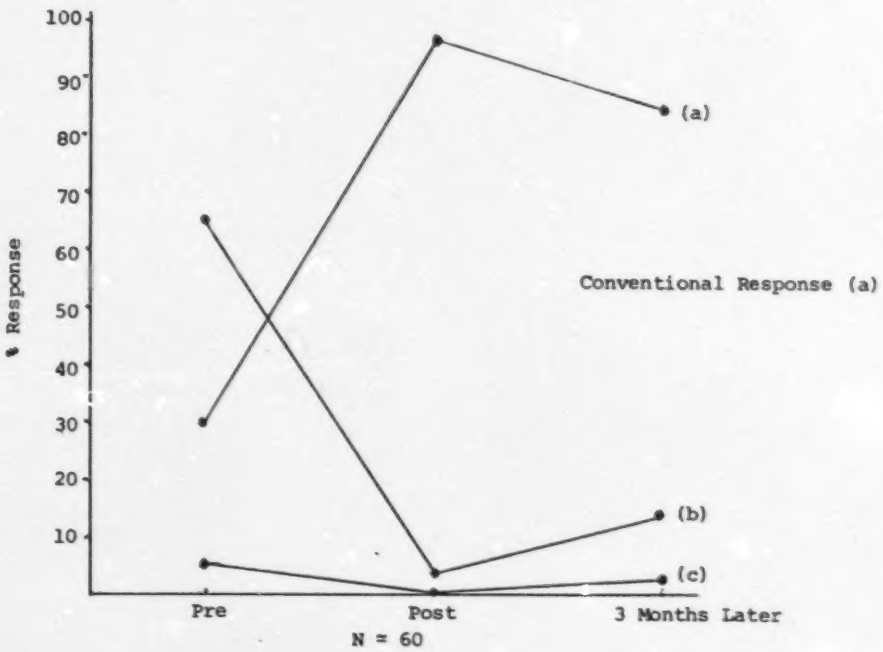


Figure 3: The Results for Question 3

Question 4: Burners were not specifically taught in this unit, so that the shift in viewpoints shown in Figure 4 is possibly more significant than in Question 3.

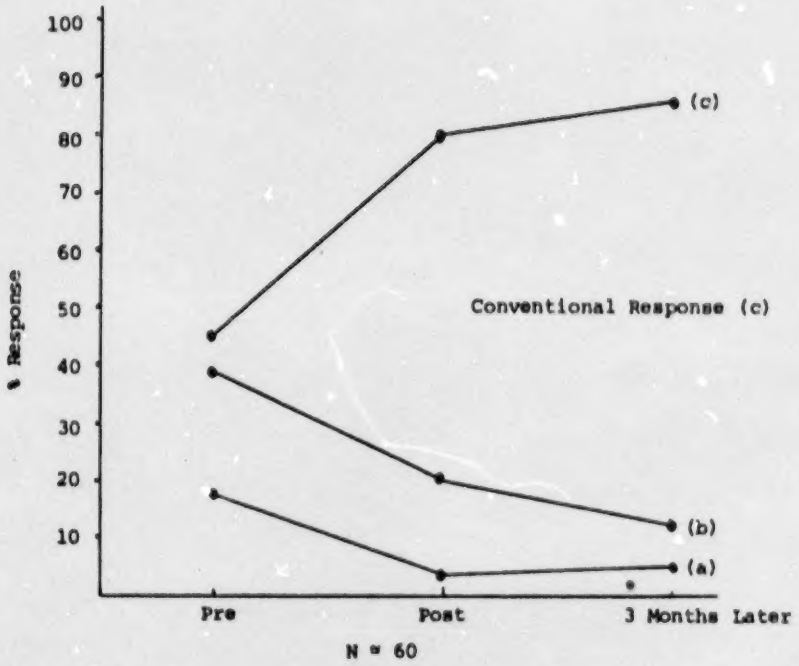


Figure 4: The Results for Question 4

In conclusion it would appear from these results that as far as ideas about candles and burners are concerned the Unit, as taught by these teachers produced a marked shift in pupils' views towards the conventional viewpoint. The results give some cause for optimism.

Heating and Cooling: The paper entitled Heating and Cooling was trialled and then modified to a form which was more widely circulated in 1982. While it is hoped that there will continue to be modifications in the Unit with time, it is useful to consider how successful the present Unit is in modifying children's ideas. The results in Table I are the combined results from four classes. The post-test results were obtained one month after teaching. A representative sample of results for classes who have not been taught the Unit is also included. The questions can be found in Appendix B.

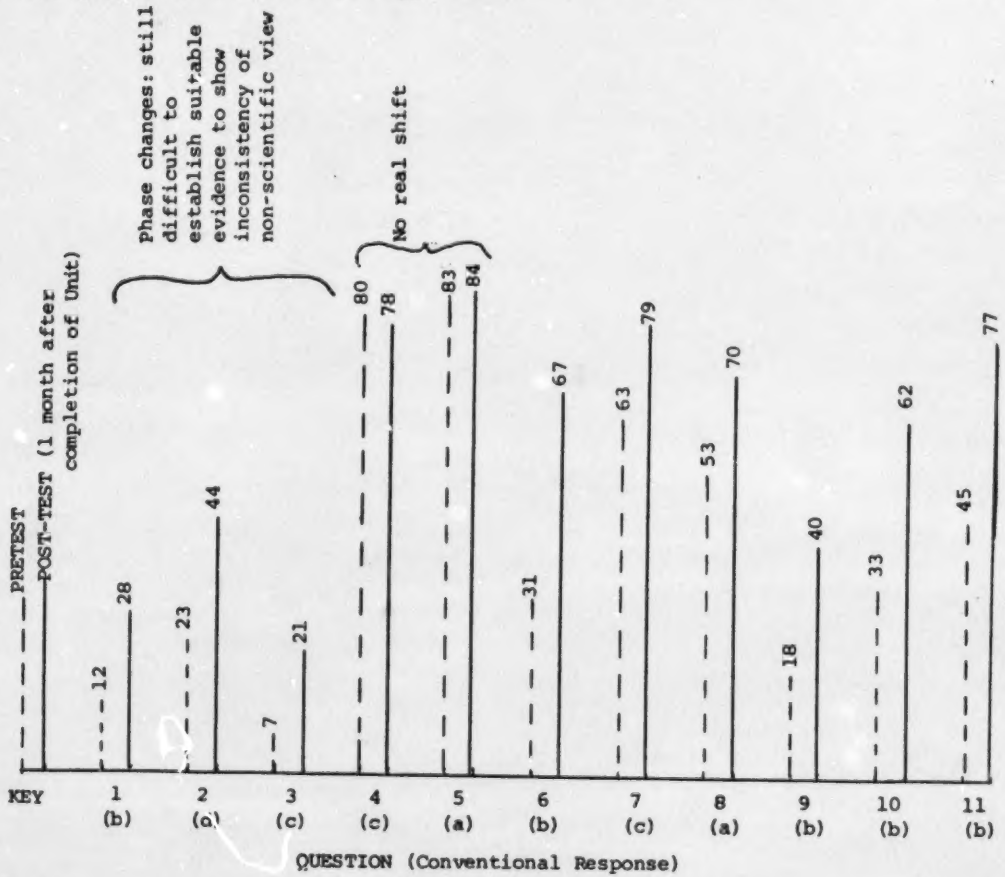


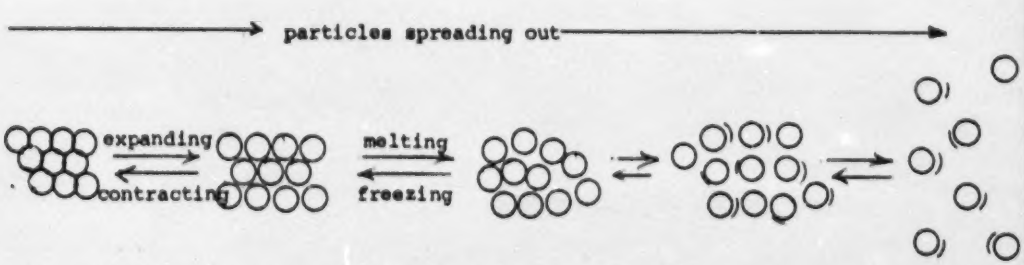
TABLE 1: Percentage conventional response of Form 3 Pupils (N = 105, 4 classes). See Appendix B for questions.

The results indicate only a marginal shift with respect to the phase changes (Q.1-4). It is considered by teachers who have tried the Unit that it is difficult to establish suitable evidence to show the inconsistency of non-scientific views. In particular, despite considerable class discussion, pupils were not convinced that evaporation of water does not involve the splitting up of water into constituent atoms (the gases oxygen and hydrogen).

There appeared to be little change with respect to Q.4 and 5. The Unit does not relate directly to these ideas and little transfer of ideas seems to have occurred. More significant changes would appear to have occurred with respect to Q.6-11.

Teachers who have taught the Unit find that children are attracted to participating in discussion when they realize the teacher was truly interested in their views and in asking why individual people held particular views. Pupils participated in the practical work/discussion because, in our view, the overview of the Unit was clear particularly after the first two activities.

One teacher at least considers that the Unit could be improved by pupils considering and discussing the following diagram.



It was also felt by some that less emphasis is required on attainment of model before the wider range of experiences is provided for pupils.

In summary it would appear that a number of improvements could be made to the Unit. However it is undoubtedly difficult to genuinely change children's ideas related to some of these phenomena (see for example Nussbaum and Novick, 1982).

CONCLUSIONS

Undoubtedly the Chemistry topics gave the Learning in Science Project team some considerable difficulty. The nature of chemistry at the school level is under considerable debate at present (see Osborne, Cosgrove and Schollum, 1982). While the results of the in-depth phase perhaps added fuel to the debate it did little to really clarify in our own minds what school chemistry should be about.

Nevertheless a stance was taken (p.2 and p.3) and the action-research phase work was begun. Undoubtedly those involved in the research were motivated by the findings of the in-depth phase as they related to Chemistry. Furthermore the group appeared to gain professional satisfaction from the work as they tried to resolve some of the problems identified; given constraints of class size, time, and equipment.

As teaching material was developed further teachers were involved in the trials of the material. In our view:

i) Teachers responded positively to the introduction of surveys which were developed to illustrate the nature, and the extent, of the views held by pupils in their classes. This information was particularly useful before teaching a Unit.

ii) Teachers were not only varying the content being taught; the teachers behaved differently. This was demonstrated within their classes, where more time was spent in determining and clarifying the views held by pupils using the survey material and generating discussion within the class. Also feedback from pupils has been positive because the activities which were planned for and carried out following initial discussion sought to reinforce or change the views held, and hence the pupils appreciated the purpose of these activities.

iii) Teachers who trialled the Units felt that information about how and what views had changed as a result of their teaching was extremely worthwhile.

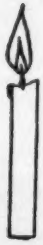
We hope that teachers who worked in the action-research group, who were involved in trialling the Units, or who simply use and improve the Units which have been produced, will continue to rethink and try to improve particular strategies to modify children's ideas. In the final analysis this is the real measure upon which the success or otherwise of the Project should be judged.

REFERENCES

Nussbaum, J. and Novick, S. A study of conceptual change in the classroom. Paper presented to the Annual Meeting of the National Association for Research in Science Teaching, April, 1982; Lake Geneva near Chicago.

Osborne, R.J.; Cosgrove, M. and Schollum, B. Chemistry and the Learning in Science Project. Chemistry in New Zealand, 1982, (in press).

APPENDIX A: A SURVEY OF SOME IDEAS OF BURNING



1. When a candle is alight,

   (a) air is needed to help the flame, but none of it is used up.

   (b) part of the air changes into something else.

   (c) air is not needed when a candle burns.

2. Consider what some people say about the wax when a candle burns. In your view, which is the best statement about the wax?

   (a) The wax is burned up in the candle flame.

   (b) The wax is not burned up; it holds up the wick as the wick burns.

   (c) The wax is not burned up; it melts and stops the wick from burning too fast.

3. A candle is put on the pan of some kitchen scales, and lit. After 60 minutes the reading on the scale would be;

   (a) less

   (b) the same

   (c) more

4. Just above the flame it is hot. What is it that is hot?

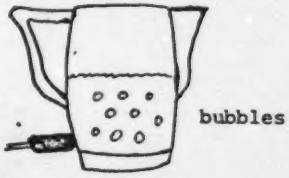
   (a) The air only.

   (b) The air and the same gas as that in the bunsen tube.

   (c) The air and at least one gas that is different from that in the tube.

The following questions are about things that happen in the home.

1. When a kettle boils there are large bubbles in the water.



What are the bubbles made of?

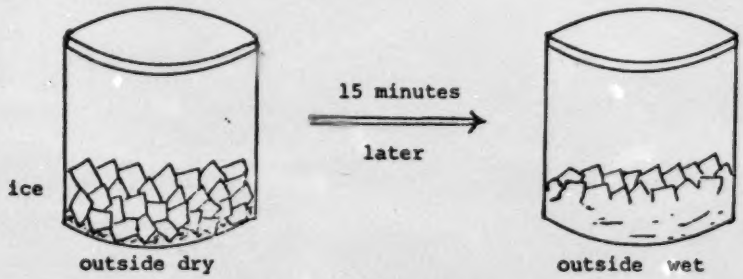
(a) Air
(b) Steam
(c) Heat
(d) Oxygen or hydrogen

2. If a wet saucer is left on the bench after it has been washed then after a while it is all dry.

What happens to the water that doesn't drip on to the bench?

(a) It goes into the saucer.
(b) It just dries up and no longer exists as anything.
(c) It changes into oxygen and hydrogen in the air.
(d) It goes into the air as very small bits of water.

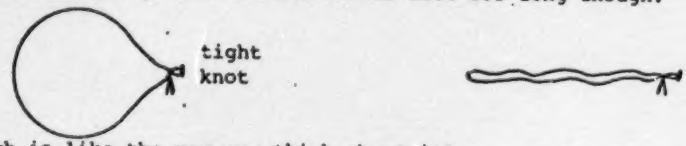
3. A small jar is filled with ice, the lid is screwed on tightly, and the outside of the glass is dried with a tea towel. Fifteen minutes later the outside of the jar is all wet.



Where has the water on the outside of the jar come from?

(a) The water from the melted ice comes through the glass.
(b) The coldness causes oxygen and hydrogen in the air to form water.
(c) Water in the air sticks to the cold glass.
(d) The coldness comes through the glass and turns to water.

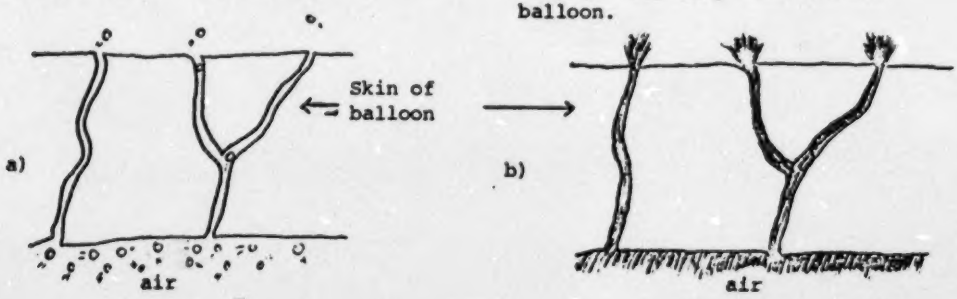
4. A balloon will go down on its own if left for long enough.



Which is like the way you think about it?

air particles escape through very tiny holes in the balloon.

air squeezes out like toothpaste through very tiny holes in the balloon.



5. We smell the scent from flowers easily. Which diagram is most like the way you think about how this happens?

a) Flower

particles from the flower spread through the room and the nose detects these particles.

b)

the scent streams out but no particles leave the flower.

The following questions are about familiar substances which are solids, liquids or gases.

6. When a thermometer is put in hot water, the liquid of the thermometer (often mercury) rises up the tube. The reason for this in your view is:-

(a) the liquid is made up of particles which get bigger as the liquid is heated.

(b) the liquid is made up of particles which move round more and spread out.

(c) the liquid is <u>not</u> made up of particles.

7. One way to show air in a bottle is like this.

A boy tries to suck all the air out of the bottle, and he manages to suck half the air out

After half the air is sucked out, he sticks his finger over the end to stop any air getting back in. Which diagram best shows how you would picture the air left in the bottle?

(a)

(b)

(c)

(d)

8. Which do you think is the best reason that the particles of the air in the flask do not fall to the bottom of a flask?

(a) The particles are always moving about.

(b) The particles are packed in so tightly that they are unable to fall.

(c) Air keeps the particles from falling.

(d) The particles are so small gravity does not affect them.

9. In a flask containing air, what is there between the particles?

(a) Air

(b) Nothing at all

(c) Gas

(d) Oxygen

10. A balloon is put over a bottle that contains nothing but air. The air is shown by the dots.

When this bottle is placed in hot water the balloon fills out.

Which of these diagrams do you think best shows what happened to the air?

(a)

(b)

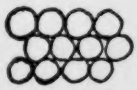
(c)

(d)

11. If we heat a solid we find it grows slightly bigger (if it doesn't melt!) One way we could picture the finest detail of the solid is shown:

Which shows best what you think happens when the solid is heated and gets bigger.

Solid particles

(a) 

the particles grow in size

(b)

the particles move round more

(c)

the particles stretch out

(d)

more particles are made by the heat